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INTEGRAL INDICATORS AS A DIAGNOSTIC TOOL FOR MULTI-SHAFT DRIVE GEARS

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The article presents the possibility of instrumental diagnostics of multi-shaft drives based on gears using integral indicators. They are formed on the basis of changes in informative frequency components (wave frequency fz, harmonics m • fz, multiples of them, and combined frequencies m • fz ± k • fo in the vicinity of the frequency of overstrain of the teeth).The use of integrated indicators reduces the amount of information analyzed and reduces the burden on the diagnostician.

From the analysis of a number of literary sources it is established that during the operation of any mechanism, the basis of which is a gear, in the spectrum of its vibrations appear characteristic frequency components of the analyzed acoustic signal, and as a diagnostic sign of the changing state of the studied object can be used not only the absolute values of these components, but also the ratio of their amplitudes [1-4]. The effectiveness of the diagnostic process itself directly depends on the number of signal components available for measurement and analysis [1]. Considering this rule and the capabilities of the implemented sample hardware-software complex [5], we obtain spectral characteristics with the number of lines up to 524000. This fact gives an advantage in diagnostics, because in the most common analyzers the resolution is up to 8000 lines, which in turn can lead to the loss of valuable information about the current state of the studied object, but it also significantly complicates the spectrum analysis process, which requires the use of automated data processing methods or application of related criteria, which were developed and applied in the course of experimental works.

The object of experimental studies, in the course of which methods of formalization of spectral characteristics were proposed, was the speed box of main motion drive of lathe SN-401 [5]. As a source of information was used acoustic signal generated by a microphone with a capsule M101.

In the analysis of the spectrum of the acoustic signal can be identified components of the acoustic activity of all elements of the drive: in the lower frequencies observed rotational and multiple components of all shafts of the kinematic chain; in the range of overlapping teeth observed toothed, multiple components of a number of cogwheels.

Processing of the obtained spectrum at its maximum resolution causes some difficulties due to a large number of elements influencing the formation of the final acoustic signal of the drive operation, and complicating the identification and analysis of harmonics at the frequencies of interest. But, despite this, there is no possibility of reducing the degree of resolution of the spectrum due to the problem of loss of data, which may carry important diagnostic information.

In order to simplify the procedure for analyzing characteristics, a program for processing measurement results was developed to identify the characteristic amplitudes of frequency components during the operation of the gear drive, on the basis of which steps were taken to simplify the process of applying diagnostic signs, given in [1,2]:

– the ratio of the sum of multiples of tooth harmonics of the analyzed wheel to the sum of the reference wheel's tooth re-pairing frequencies:

$$K_z = \frac{\sum_{i=1}^{5} A(f_{zi})}{A(f_{zi})_{ref}} \tag{1}$$

– the ratio of the sums of amplitudes of the combined frequencies of the analyzed wheel to the sum of amplitudes of the revolving frequencies of the reference wheel K_{bp}:

$$K_{bp} = \frac{\sum_{i=1}^{5} A(f_{zi} \pm nf_o)}{\sum_{i=1}^{5} A(f_o)_{ref}} \tag{2}$$

The results obtained using serial wheels are taken as a reference. On the experimental gear Z=43, located on shaft II, a tooth chip was simulated (25%, 50% and 75% of the toothed part and without a tooth) as the most dangerous defect.

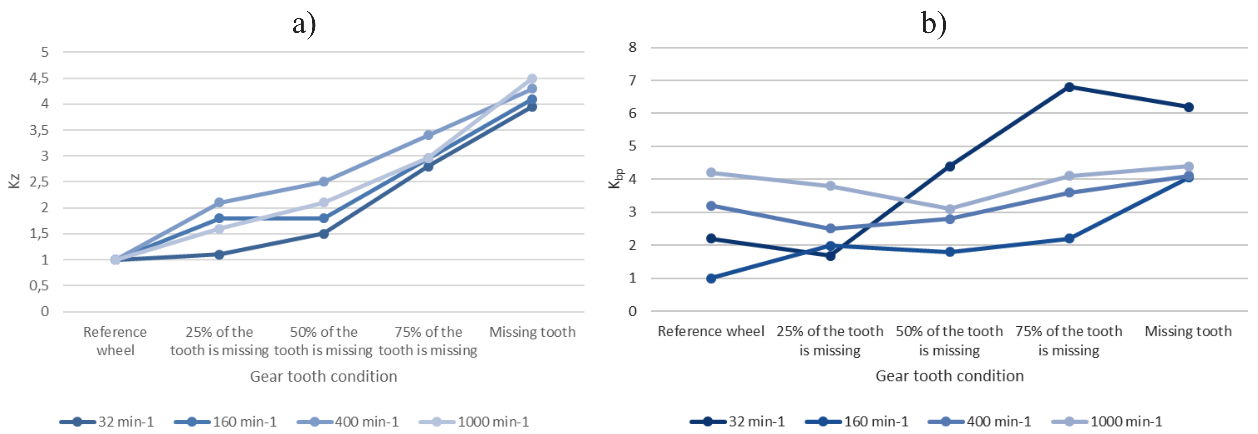

Figure 1 – Diagrams of changes in K_z (a) and K_{bp} (b) values for wheel Z=43 in different gears and at different degrees of defect development

As a result of analysis of the values of the proposed indicators, we can draw the following conclusions:

– change in the value of the relative coefficient K_z compared with the reference wheel, indicating the presence in the acoustic signal relatively high-amplitude harmonics at frequencies multiple of gear tooth frequency of the studied gear. The reason for such amplitude distribution is the emergence of a local defect, and with the growth of its development there is a more intense growth of amplitudes at these frequencies [1,2];

– the change in the value of the relative coefficient K_{bp} in comparison with the values of the reference wheel, indicates a higher amplitude of the lateral combined frequencies to the amplitude of the revolving frequency of the reference wheel f_i. This is possible when deviating from the normal state of the studied gear because of the loss of the working surfaces of the teeth of their original performance characteristics, which further leads to the emergence of profile error [1,2].

Thus, together with the developed technique of automatic processing of the spectral characteristics and the offered integral indices K_z and K_{bp}, on which dynamics of change of values it is possible to judge about a current condition of the investigated drive, there is a simplification procedure of diagnosing of various defects of gears and elements of multi-shaft drives in the course of their operation without disassembly.

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